Chondromyces aurantiacus (B. & C.)

Fig. 25. General appearence of a portion of rod mass growing in fluid agar. Fig. 26. Living rods from active rod-mass. *a*, rod dividing. Fig. 27. Vegetative rods in glycerine (*a*) showing granular contents stained with borax carmin. Fig. 28. Rods isolated in mature crushed cysts.

Myxococcus coralloides n. sp.

Fig. 29. Highly developed spore mass. Fig. 30. Spore mass of a different form more highly magnified. Fig. 31. Spore mass rising from rod mass at its base. Fig. 32. Vegetative rods. Fig. 33. Mature spores. *a*, spores in process of formation.

PLATE XXV.

Myxobacter aureus n. sp.

Fig. 34. General habit showing four cysts embedded in gelatinous matrix. Fig. 35. Rods (living) from rising rod-mass. Fig. 36. Rods from cysts crushed at maturity.

Myxococcus rubescens n. sp.

Fig. 37. General appearance of young spore mass viewed from above and surrounded by vegetative rods. Fig. 38. Normal habit of spore mass viewed laterally. Deliquescence beginning at the top. Fig. 39. Vegetative rods. Fig. 40. Different stages of supposed spore formation. Fig. 41. Mature spores.

Development of the flower and embryo-sac in Aster and Solidago.

G. W. MARTIN.

(WITH PLATES XIX AND XX.)

Concluded from page 358.

Let us now turn to the development of the ovule and the embryo-sac. A short time before the floral organs attain their maximum length, there appears at the bottom of the ovarian cavity a rounded excrescence; this is the incipient ovule, the promise of a future seed (fig. 11).[6] This incipient ovule does not arise from the bottom of the ovarian cavity, but a little above the lowest point. Therefore, the ovule is not the terminal structure on the floral axis. For, by careful focusing, the apex of the fascicular system is seen to end very abruptly at the bottom of the ovary cell. To the right and left of the axial bundle of the pedicel, a little below the apex, are given off fibro-vascular bundles which traverse both sides of the carpellary leaf. It is in the region of one of these lateral bundles, beneath the epidermis, that the primitive cells develop, which arch upward and give rise to the funiculus and the nuclear ovule. Subsequently, a branch of this lateral bundle

---

[6] The ovule somewhat advanced.

enters the funiculus. According to the investigations of Sachs and others, made upon the Compositæ, we have the assertion that the nuclear ovule is a lateral out-growth of the funiculus, but this statement could not satisfactorily be verified by my study of the two genera under investigation. As to the question whether the ovule is a lateral outgrowth on the flower axis there can be no doubt.

So far as could be determined no trace of evidence showed the ovule to be a direct outgrowth on the axis, but on the other hand, an outgrowth on the leaf. Returning again to the early growth of the ovule, as before stated, that it first appears as a rounded excrescence surmounting the funiculus. At first the ovule consists of a mass of cells, the tissue of which is soft and cellular, and is designated the nucleus of the ovule or the nucellus. By further development a large nucleated cell appears within this nucellar tissue, which soon divides, the apical cell of which becomes the mother-cell of the embryo-sac (fig. 12a). In its early development the nucellar body is almost orthotropous, but by further growth it becomes curved (caused by a stronger growth on one side) at the point (base of the nucellus, where the integument originates (fig. 12 b)[7]. At first the integument appears as an annular ring; as growth takes place it forms a complete wall around the nucellus; as the wall encroaches upon the apical portion of the nucellus, the latter becomes more and more curved, but does not seem to be wholly inverted till the integument completely surmounts it, even passing far beyond the nucellar apex (fig. 16). Thus, we have an ovule which is anatropous; having a single integument, though very thick and forming the greater mass of the ovule before fertilization is accomplished, investing a small central portion, the nucellus (fig. 13a)[8]; and the latter, which consists of but one layer of cells, in turn surrounds a more central portion, the embryo-sac (fig. 13b). Originally, this sac consists of but a single nucleated-cell, which, when division is complete, forms a central row of four cells (fig. 16). The nucellus in process of growth becomes very much elongated; its cells are well defined and nucleated; likewise the mother-cell of the embryo-sac, though primitive-

[7] Advanced stages of the ovule.

[8] At this point it may be stated that the integument does not develop on the side next the funiculus; this is common with anatropous ovules.

ly polyhedral in outline, but later more oval in contour, elongates and contains a nucleus with nucleolus imbedded in a rich mass of protoplasm. In some sections the nucleus appeared to be elongated in the same direction as that of the embryo-sac. During the subsequent growth of the integument and nucellus the embryonal sac enlarges (figs. 13 and 14), and the nucleus of the mother-cell undergoes subdivision. In fig. 15 the nucleus has divided, and the mother-cell is now separated into two equal parts by a transverse wall, each part containing a nucleated-cell. Presently, the two nuclei divide, a transverse wall is formed in each half, and thus we have, at the end of the second and last subdivision of the mother-cell of the embryo-sac, four equal nucleated-cells (fig. 16). At this stage of the embryo-sac there is a very close analogy to the division of the mother-cell into four cells, worked out by Strasburger in Polygonum and Senecio. The cross walls formed between the cells are very strongly refractive and much swollen; the middle transverse wall is remarkably distended and persists much longer than the other two partitions; in several sections the middle wall was found intact when the coutents of the cells were completely absorbed.

Of the four cells into which the primitive mother-cell of the embryonal sac is now divided, only the lower one is characterized by further growth;[9] this cell, therefore, becomes the true mother-cell of the embryo-sac (fig. 17,*a*). Subsequently, the protoplasm of the upper three cells becomes viscid, the nuclei show disintegration, and the upper wall of the lower, club-shaped cell (mother-cell) indicates a rigid turgescence. When the upper three cells begin to disorganize (in centrifugal order), they become crescent-shaped; their nuclei disappear, their walls are displaced, and the cell contents are absorbed by the encroachment of the lower, mother-cell. After the cells are completely disorganized and absorbed, the mother-cell assumes a central position in the embryo-sac (fig. 18). Simultaneously with the obliteration of the upper cells of the embryo-sac, the one-cell-layer of the nucellus undergoes a similar process of disintegration. The first mark of displacement is shown by the reduction of the cell contents to a granular protoplasmic mass; then follows the disappearance

[9] The micropylar end is known as the upper extremity of the ovule, while its opposite is the lower end.

of the transverse cell walls (fig. 18). The order of nucellar displacement begins at the apical end of the nucellus and proceeds toward its basal portion (fig. 19); finally, the whole nucellar-tissue is displaced and absorbed by the embryo-sac, which subsequently becomes very much enlarged. In fig. 19 is seen a partial obliteration of the nucellus and at this period of growtn the embryo-sac is completely filled with protoplasm, in the central portion of which is located the mother-cell with a vacuole both above and below it. Fig. 20 shows a complete displacement of the nucellus and elongation of the embryo-sac; a farther separation of the vacuoles; the first division of the mother-cell into two daughter cells, each moving, the one into the upper, the other into the lower end of the embryo-sac. In the next stage of development we have the first division of the polar nuclei, thus making two nuclei in each end of the embryo-sac. The two upper nuclei rest within an accumulation of protoplasmic substance, while the two lower nuclei rest within a less dense plasma between an upper and a lower vacuole which show a longitudinal expansion (fig. 21). Previous to the last division of the polar nuclei, a longitudinal increase of the whole embryo-sac takes place. Subsequently, each of the two nuclei divide and we have four nuclei occupying opposite extremities of the embryo-sac. Thus, division is complete, and the upper cells give rise to the egg-apparatus, while the lower are designated antipodal cells. The next stage of development, as in fig. 22, is characterized by the ascent of one of the antipodal cells toward the center of the embryo-sac. This nucleus is imbedded in a dense mass of protoplasmic material separating two large vacuoles. Of the three antipodal cells remaining, the two upper, which lie alongside and impinge on each other, also rest in a plasma bridge separating two vacuoles, the upper of which is the larger and the lower one of the two previously mentioned. The lowermost cell is partly obscured by the impingement of the lowermost vacuole. At the micropylar end of the embryo-sac the cells have a far different significance; one of the cells in its descent toward the center of the sac meets its fellow from below and both coalesce, thus forming a secondary or endosperm nucleus. The three remaining cells, though naked like the three opposite, but surrounded by a denser mass of protoplasm, constitute the true egg-apparatus. The two upper cells of the egg-apparatus, which lie side by side occupying the whole tapering anterior end of the embryo-sac, are the synergidae; at their lower extremity, extending nearly across the sac, lies a larger rounded cell, the oosphere. In further development, as found in fig. 23, the embryo-sac becomes very much swollen, which is a characteristic feature both before and after the process of fertilization. But fertilization in this case has not yet been accomplished, as the perfectness of outline of the synergidae amply testify. The upper vacuole of the preceding figure shows a contraction toward the upper extremity of the embryonal sac and is more oval in outline. At this stage, also, the upper polar nucleus exhibits retarded action in its descent toward its counterpart from below, in many cases refusing descent till after or about the fertilization period.

To trace the embryonal sac in its further development would result in recounting what, already, is very familiar to many botanists.

Summary.—I. The calyx appears second in order of succession of the floral whorls.

II. The syngenesious anthers seem to be united structurally.

III. The upper polar nucleus shows a slow descent in uniting with the lower one to form the endosperm nucleus.

IV. Compared with Strasburger's study of Senecio the following differences were observed:

(1) The antipodal cells occur in no regular order, and as far as my investigations went, were never found arranged in a single longitudinal row.

(2) No more than four antipodal cells could be discovered, always naked and having no cross walls.

(3) The oosphere, as far as could be determined, failed to occupy the whole diameter of the embryo-sac.

(4) The nuclei of the cells composing the egg-apparatus seemed always to occupy an almost central position.

(5) Vacuoles were seldom seen in the synergidae.

All figures illustrating the development of parts given are from sections supposed to pass through the center of the tissue which they represent.

All material used was fixed in 1 per cent. chromic acid 24 hours, thoroughly washed, stained *in toto* with alum carmine 24 hours, again washed and dehydrated; then taken through the xylol-absolute-alcohol process into a saturated solution of xylol and paraffine, then infiltrated with paraffine, imbedded, and sectioned with a microtome; again, the sections were counter-stained on the slide with Bismarck brown and mounted in xylol-balsam.

Acknowledgments are due Dr. John M. Coulter and Mr. D. M. Mottier of Indiana University for their valuable suggestions given in the direction of my work.

Indianapolis High School.

A vacation in the Hawaiian islands.

DOUGLAS HOUGHTON CAMPBELL.

As the vacation approached, the question arose, "Where shall I go for the summer?" With the numerous interesting regions within comparatively easy reach of San Francisco, this question was not to be answered without some deliberation; but finally the Hawaiian islands were decided upon, as promising much of interest, both botanical and otherwise.

Hillebrand's Flora of the Hawaiian islands was procured; from it I obtained some idea of what might be expected in the way of vegetation, and with much interest I looked forward to the moment when, for the first time, I should find myself roaming in a tropical forest.

On the 6th of July, behold me, then, a passenger on the Australia, bound for Honolulu. There is very little to record of the voyage, which was pleasant enough but not eventful. One is struck by the paucity of life in the Pacific after getting away from the immediate vicinity of land. None of the giant kelps, so characteristic of the coast region, were seen after the first day out, nor was any floating sea-weed observed during the trip. Animal life was confined to a few sea-birds, mostly "gonies," small brown albatrosses, which followed the ship for several days. As the warmer waters were reached, flying fish became abundant, but they were pretty much the only animals noted on the way over. Not a vessel of any kind was seen after the first day, and the vast stretch of blue water was unbroken by any sign of life. The water is enormously deep, and of a blue so vivid, that one can almost believe that a handkerchief dipped into it would come out blue.